



Ladder rungs – A strategic and tactical tool

The race course for sailboats is similar to a playing field for baseball or football, but in sailing there are no foul lines or yard markers visible on the course. For critical boundaries like the starting line or the zone around a mark, sailors have to rely on their best judgment and imagination.

Of course, most racers would love to see certain guides like laylines and start or finish lines painted on the water surface. But the most useful markers, at least for strategy and tactics, would be what sailors commonly refer to as 'ladder rungs.'

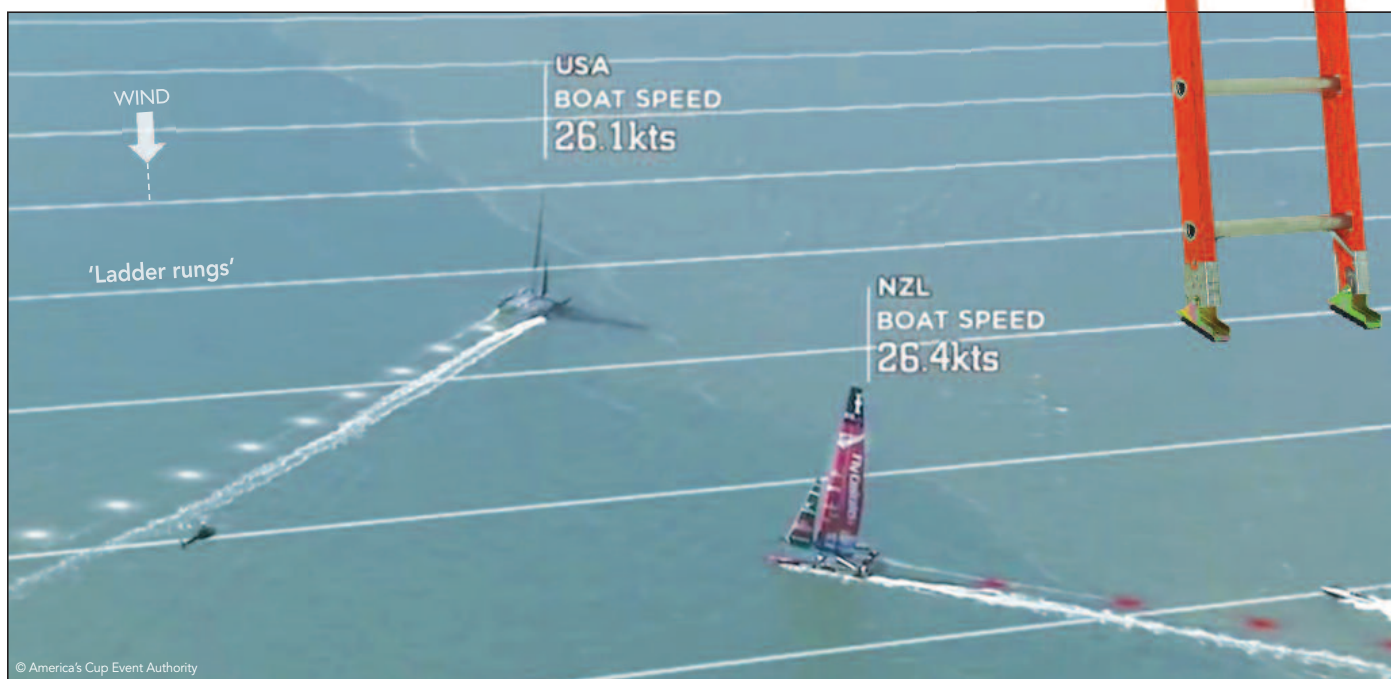
To understand this concept, imagine a very wide ladder superimposed on the race course. The sides of the ladder are lined up parallel with the wind direction, and the ladder rungs are perpendicular to the wind (see photo). Boats sailing upwind have to climb *up* the ladder to get to the windward mark. Boats sailing downwind must climb *down* the ladder toward the leeward mark.

Though ladder rungs are invisible like all other sailing markers, they can help sailors understand a lot about wind shifts, their position in the race, favorite ends of the start and finish lines, and more. That's what the rest of this issue is all about.

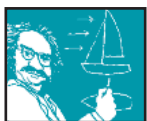
ISSUE #138

'LADDER RUNGS'

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The AC Liveline graphics that were used for the broadcast of the 34th America's Cup in San Francisco Bay were fantastic! The superimposed ladder rungs were especially helpful for understanding the race course and seeing which boat was ahead and by how much. They showed how this tool can be valuable for racing sailors.

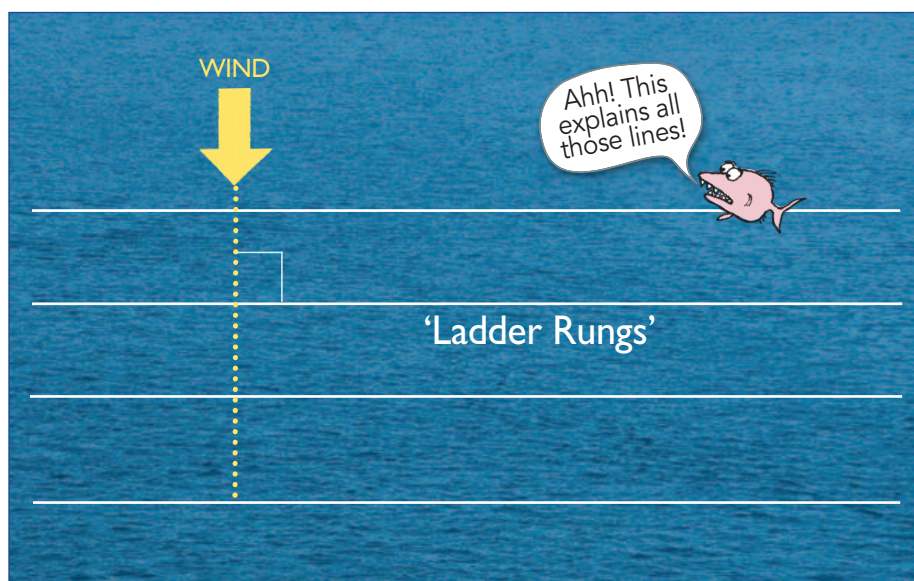


IN THEORY

Ladder rung principles

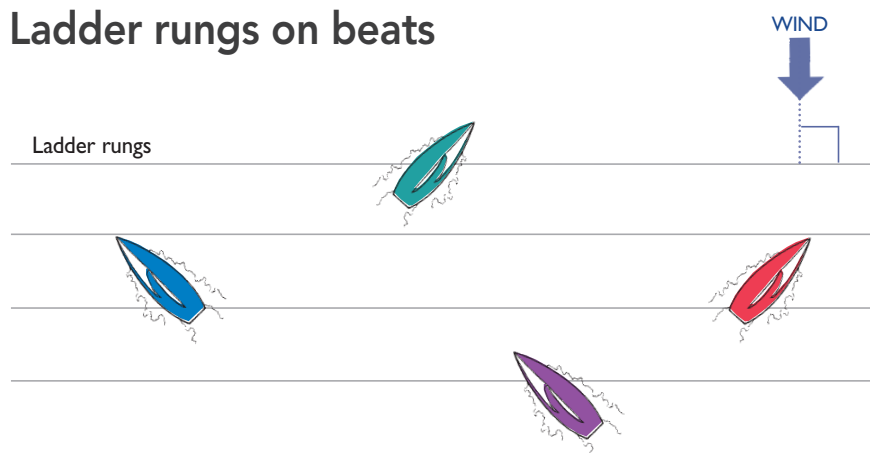
Ladder rungs are imaginary tools that sailors can use to judge the positions of boats on the race course and understand what happens when the wind shifts. This concept applies both upwind and downwind, whenever a boat's proper course is to maximize its performance in a direction toward or away from the wind.

Ladder rungs don't apply on reaches or when a boat overstands the next mark – therefore we will assume during this issue that boats are sailing within the laylines on windward or leeward legs. We will also assume that boats don't lose distance when tacking or jibing – by doing this we can discuss ladder rungs without worrying about what tack each boat is on. Here are some very basic principles for starters.



Ladder rungs are always parallel to each other and perpendicular to the direction of the wind in which the boats are racing (their 'sailing wind'). The exact spacing between rungs usually doesn't matter too much for most ladder rung concepts.

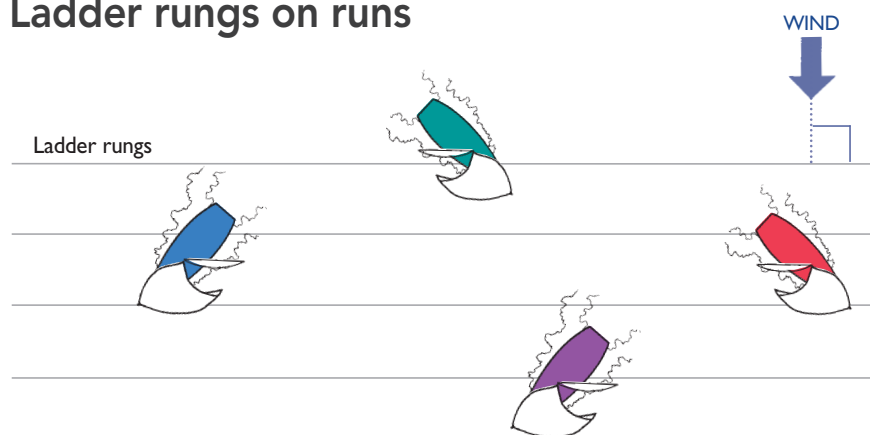
Ladder rungs on beats



When you're racing to a windward mark, the object is to climb up the ladder and get to higher and higher ladder rungs until you reach the mark (which is on the top rung). Therefore, boats that have progressed farther up the ladder (in a direction to windward) are ahead of boats that have not climbed as far.

In this example, Green is ahead of Purple, and Red is behind Green. Blue and Red are on the same ladder rung; this means they've made equal progress to windward so they are even in the race.

Ladder rungs on runs



When you're racing to a leeward mark, the object is to climb down the ladder and get to lower and lower ladder rungs until you reach the mark (which is on the bottom rung). Therefore, boats that have progressed farther down the ladder (in a direction to leeward) are ahead of boats that have not descended so far.

In this example, Purple is ahead of Green, and Blue is behind Purple. Blue and Red are on the same ladder rung; this means they've made equal progress to leeward so they are even in the race.

Why care about ladder rungs?

Ladder rungs are invisible and, unlike starting lines and the zone around marks, they don't have any legal standing. So what makes them a valuable tool?

Sailboat racing is a challenge in part because there are no lines on the playing field and you can't see the wind. For many sailors it's hard to grasp where they

are in the game and what happens when the wind direction changes (as it almost always does).

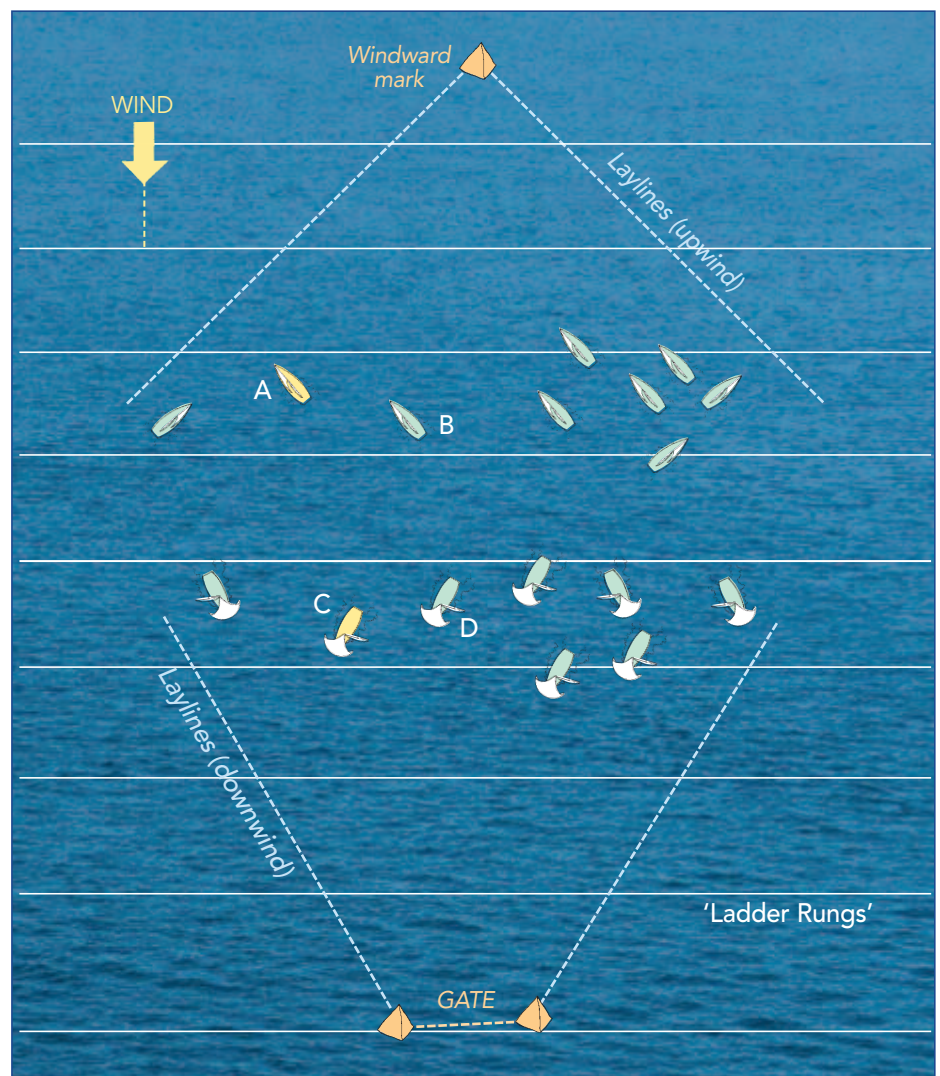
The concept of ladder rungs adds structure and logic to the sailors' playing field and competition. It explains how many things work and helps sailors with a number of strategic and tactical choices.

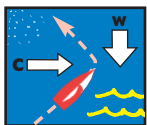
A good understanding of ladder rung theory will help you do a better job of:

1. **Judging how you are positioned in the race.** Are you 10th, or 20th? Closer to the front or the back? Knowing where you stand helps you make decisions about how much risk you should take at any point.
2. **Assessing potential tactical moves.** If you tack or jibe, can you cross in front of the boat on your hip? Where will you come out relative to that pack of boats a minute or two away? The answers to these questions may have a large bearing on the tactical choices you make.
3. **Understanding how wind shifts work.** Ladder rungs make it easy to understand why you should sail toward the next shift upwind and away from the next shift downwind.
4. **Evaluating start lines, finish lines and gates.** The favored end of a line or gate is the one that's on a higher ladder rung if it ends a leeward leg, or on a lower ladder rung if it ends a windward leg.

'Ladder rung theory' can help you answer questions like these:

1. How well is A (or any other boat) doing in this race?
2. If A tacks, can she cross ahead of B? Where will she be relative to the pack of boats on the right side?
3. If the wind shifts a certain number of degrees to the left (or right), how much will A gain (or lose) relative to B and the rest of the fleet?
4. If these boats are racing toward an upwind finish line, which end of that line will be favored?
5. If C jibes, can she cross ahead of D? Where will she be relative to the pack of boats to her left?
6. If the wind shifts a certain number of degrees to the right (or left), how much will C gain (or lose) relative to D and the rest of the fleet?
7. Which gate mark is favored?
8. If they're racing toward a downwind finish line, which end of that line will be favored?





STRATEGY

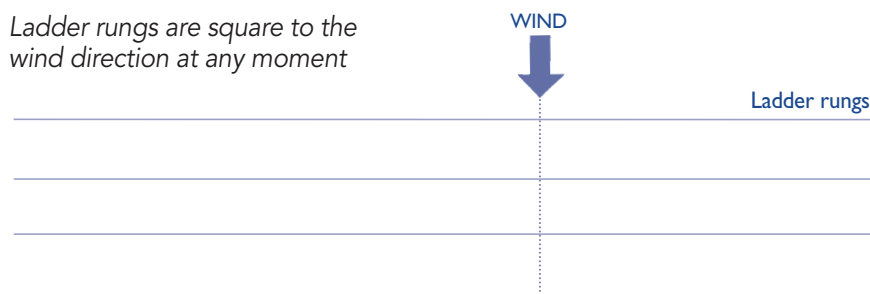
Ladder rungs and windshifts

Ladder rungs are great tools for understanding how the wind direction affects boats racing upwind or downwind. On most days the wind shifts constantly, even when it seems relatively steady, so ladder rungs (and the corresponding positions of boats in the fleet) are also changing continuously.

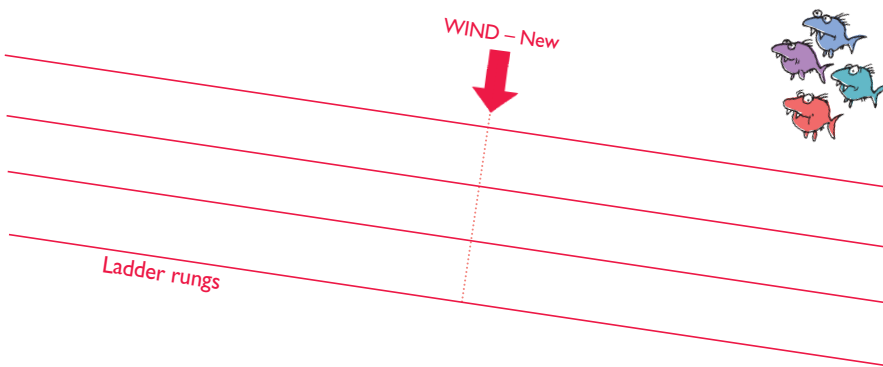
Whenever the wind changes direction, the boats that are closer to that shift move up the ladder, while boats farther away from it move down the ladder. Climbing up is good when you're sailing upwind, but climbing down is the goal when sailing downwind. The basic rule of thumb, therefore, is to be closer to the next shift on a beat, but farther away from it on a run (see page 5).

Ladder rungs are a function of wind direction, but they're not affected by wind velocity. Of course, wind pressure does affect how high or low boats can sail both upwind and downwind. This makes their angles look different, but it doesn't affect ladder rungs (see page 15).

Ladder rungs are square to the wind direction at any moment

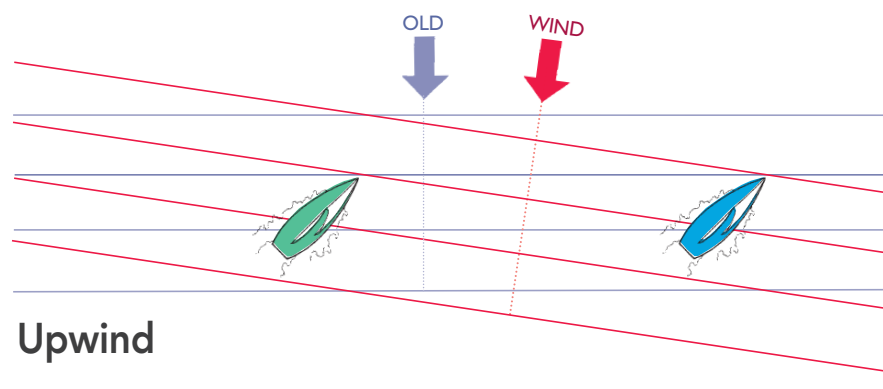


When the wind changes direction: Since ladder rungs are always lined up perpendicular to the direction of the wind, their angle changes whenever the wind shifts. If the wind goes right (below), the ladder rungs tilt a corresponding amount that way. Since the wind direction seldom stays constant for very long, ladder rungs are also constantly moving, and this can have a big impact on strategy and tactics.



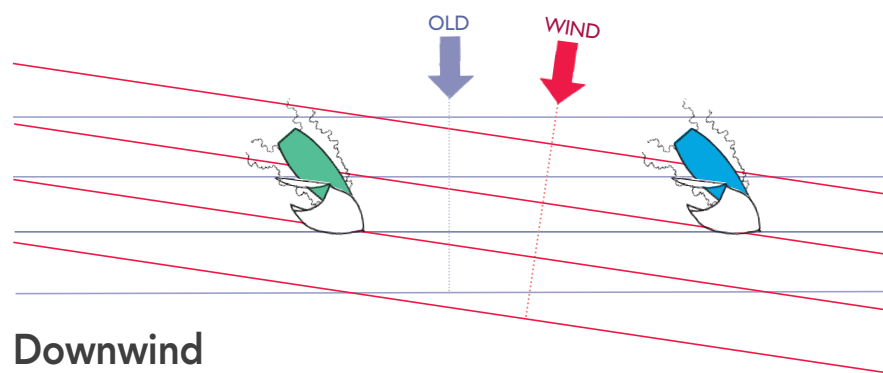
In the old breeze, Green and Blue were on the same ladder rung, so they were even in the race. When the wind shifted to the right (red arrow), the ladder rungs also shifted accordingly.

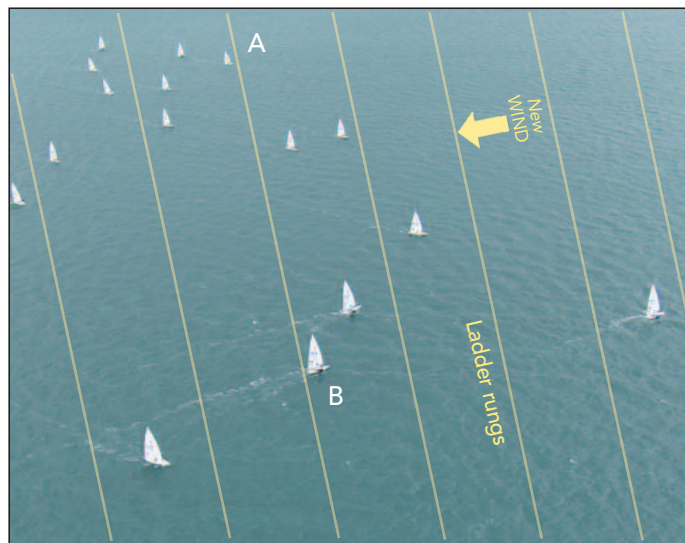
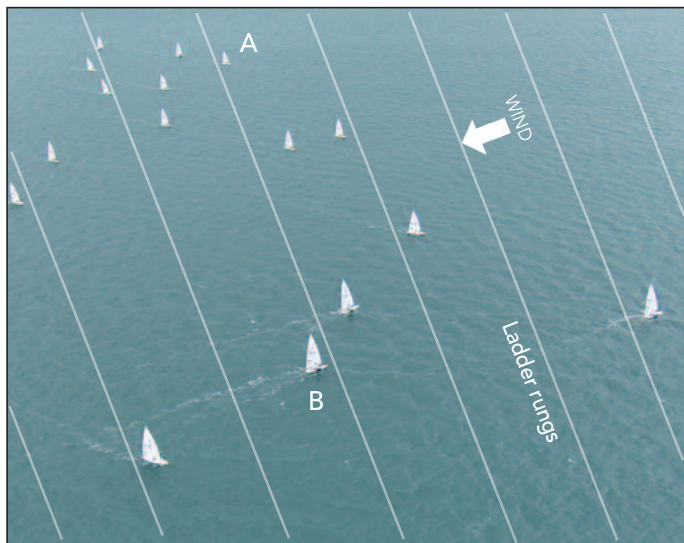
Whenever the wind changes direction, the boat that is closer to the new wind (Blue in this case) always ends up on a higher ladder rung. Since being on a higher ladder rung is good when you're racing upwind, this means Blue is now ahead of Green in the race.



On this downwind leg, Green and Blue were originally on the same ladder rung, so they were even in the race. When the wind shifted right (red arrow), the ladder rungs also shifted accordingly.

Whenever the wind changes direction, the boat that is closer to the new wind (Blue in this case) always ends up on a higher ladder rung. Since moving to a higher ladder rung is bad when you are racing downwind, this means Green is now ahead of Blue in the race.





Upwind: Sail toward the next wind shift

When you're racing to a windward mark, the goal is to climb *up* the ladder rungs as quickly as possible. We know from ladder rung theory that when the wind shifts, the boat that's closer to the new wind direction will move to a higher ladder rung. Therefore, you should sail *toward* the next shift. By doing so you will gain on boats that don't do this; the amount you gain will be proportional to the size of the shift and the amount of separation between you and other boats.

A fleet of Lasers is racing upwind (*above left*). By looking at ladder rungs, we can see that Boat A is slightly ahead of Boat B (because A is farther up the ladder). However, the boats are quite far apart, so even a small windshift could have a big impact on their relative positions.

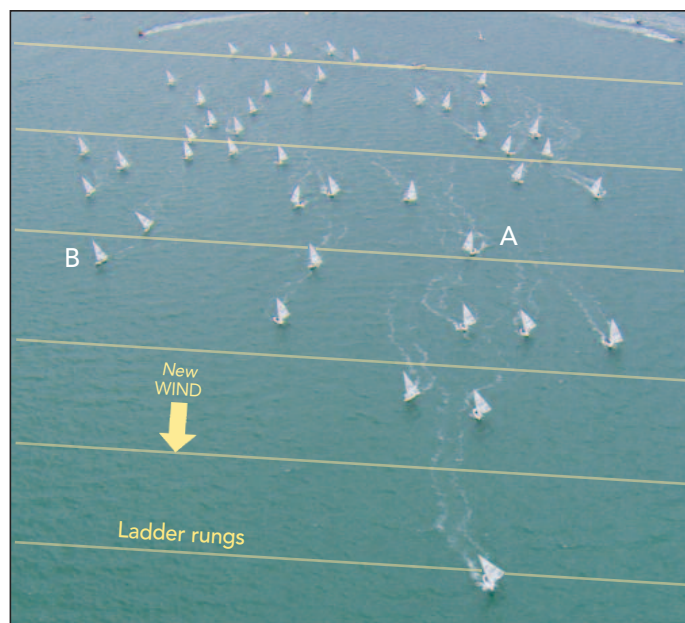
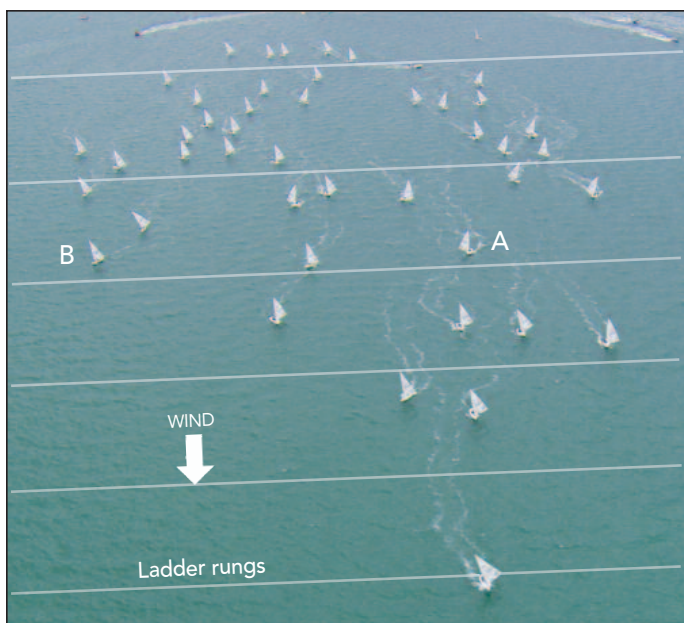
Then the wind shifts slightly to the right (*above right*). Boat B is closer to this shift, so she gains and A loses. By drawing new ladder rungs for this wind direction, we see that B is now ahead of A.

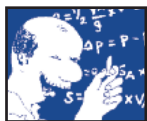
Downwind: Sail away from the next wind shift

When you're racing to a leeward mark, the goal is to climb *down* the ladder rungs as quickly as possible. Ladder rung theory says that when the wind shifts, the boat that's closer to the new wind direction will move to a higher ladder rung. Therefore, on a run you should sail *away from* the next shift so you end up on a lower ladder rung when the shift comes. By doing so you will gain on boats that don't do this.

A fleet of Lasers is racing downwind (*below left*). By looking at ladder rungs, we can see that Boat A and Boat B are fairly even in the race (because they are both equally far down the ladder).

Then the wind shifts to the right (*below right*). Boat B is farther from this shift, so she gains and A loses (the amount depends on lateral separation and size of the shift). By drawing new ladder rungs for this wind, we see that B is now ahead of A.



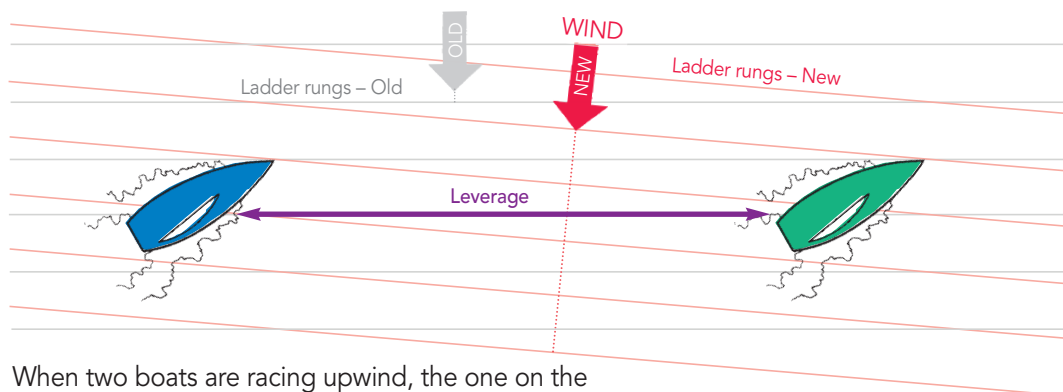


IN THEORY

Ladder rungs and 'leverage'

We've been talking about a giant ladder superimposed on the race course which provides a great picture of where each boat stands relative to the rest of the fleet. The ladder rungs show which boats gain and lose when the wind shifts, but they don't say anything about *how much* they gain or lose.

That depends on 'leverage,' a measure of the lateral distance between boats. This concept of leverage is very important tactically and strategically because it determines how much you will gain or lose to other boats when the wind shifts. The more leverage, the more that wind shifts affect positions.



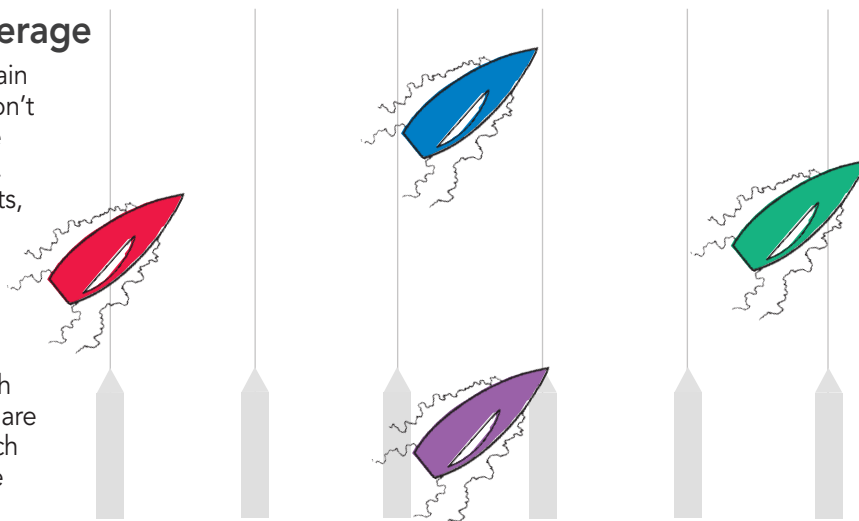
When two boats are racing upwind, the one on the higher ladder rung is ahead. If they are both on the same ladder rung they are equal in the race, at least until the wind direction changes. When the wind shifts, one boat gains and the other loses (the boat closer to the shift gains upwind while the boat farther from the shift gains downwind). The amount of gain or loss depends on two things: 1) the size of the shift; and 2) the lateral distance (i.e. 'leverage') between the boats.

Use 'fence posts' to estimate leverage

When you want to know how much a boat will gain or lose in a wind shift, horizontal ladder rungs won't help – you need to imagine vertical lines that are parallel to the wind direction. Think picket fence.

The more fence posts there are between boats, the more they are leveraged against each other, and the more they will gain or lose when the wind direction changes.

In this example, the Blue and Purple boats are on essentially the same fence post, so when the wind shifts neither boat will gain or lose much to the other. Red and Green, on the other hand, are separated by quite a few fence posts so they each have a lot of leverage. When the wind shifts, one will gain a lot and the other will lose a lot.



Gain and loss upwind in shifts

Your boat's tacking angle	Size of wind shift			
	5°	10°	15°	20°
90°	12%	25%	37%	48%
80°	11%	23%	34%	45%
70°	10%	21%	31%	42%

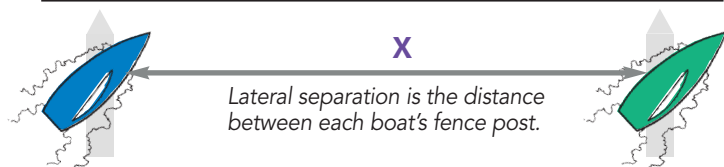
Gain or loss as a % of lateral separation (X)

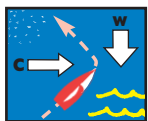
The mathematics of leverage and shifts

Here's a chart that shows how two boats racing upwind will fare when the wind shifts in increments of five degrees. As you can see, the amount of gain and loss depends on the size of the shift and the lateral separation between boats (as well as the boats' tacking angle).

As an example, consider two boats (Blue and Green) that tack through 70° and are about 20 boatlengths apart on a beat. Then the wind shifts 10° to the right. The Green boat will gain, of course, because she is closer to the shift. The amount she gains will be about 21% of 20 boatlengths, or about 4 boatlengths!

We can make this much simpler so it's easy to remember. As a rule of thumb, a wind shift of Z degrees produces a gain that is roughly $2 \times Z\%$ of the separation between boats. In other words, a 5° shift produces a gain of twice that, or 10%. A 10-degree shift means a gain of 20%. These gains can be quite big when boats have a lot of leverage.





STRATEGY

Ladder rungs at the starting line

Ladder rungs are a perfect tool for understanding the geometry of a starting line because one of the most critical things to know about any line is whether or not the two ends of the line are on the same ladder rung. When the start is to windward (which is the case most of the time), the goal is to climb up the ladder as fast as possible toward the windward mark. If one end of the line is on a higher ladder rung, you can start there and get a head start on all boats that start farther away from it. So it's key to know the angle of the start line relative to ladder rungs.

Starting line 'bias'

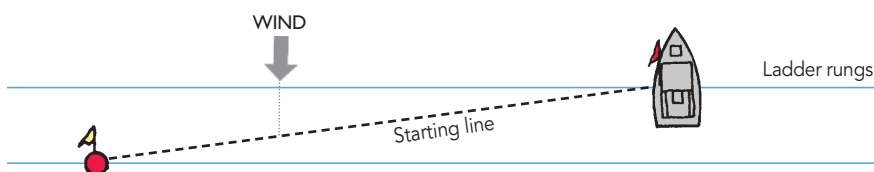
When the starting line is not square to the wind (i.e. it is biased or skewed), it's critical to know how much distance you would gain or lose by starting at either end. You can calculate this amount with the same math we used for windshifts.

For a starting line, the lateral separation is the length of the line (often about 1.5 times the number of boats). The 'wind shift' is the line bias (i.e. the difference between the actual wind direction and the wind needed to make the line square).

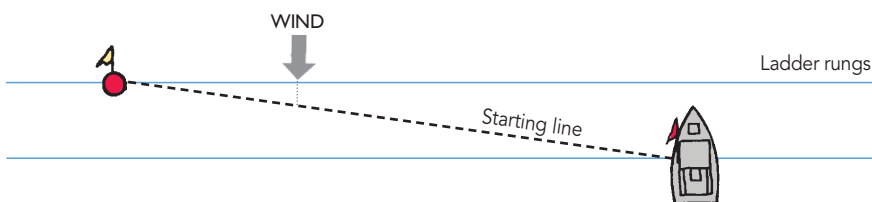
Consider a starting line that is about 40 boatlengths long with the pin upwind by 5°. A boat starting there will be roughly 4 boatlengths ahead of a boat starting at the other end (using the chart at left).



▲ A typical starting line is set 'square' to the wind, which means it makes a 90° angle with the wind direction. Ladder rungs are also perpendicular to the wind, so a square starting line is the same as a ladder rung. This means boats starting anywhere on this line are equal in the race. Of course, a starting line will be square to the wind only as long as the wind direction doesn't change. As soon as the wind shifts the ladder rungs also shift, which means the start line is no longer a ladder rung and not all boats on the line are equal. That's when you have a 'biased' line with a 'favored' end, so it's key to keep track of wind shifts as you get closer to the start.



When the wind is not square to the starting line, the ends of the line are on different ladder rungs. In the example above, the committee boat is on a higher ladder rung than the pin, so boats starting there are ahead of (i.e. they are advanced farther to windward than) boats at the pin. In the example below, the pin end is on a higher ladder rung so that end is farther advanced up the beat. At a windward start, the end of the line on the higher ladder rung is 'favored' (not considering other strategic factors on the first beat).



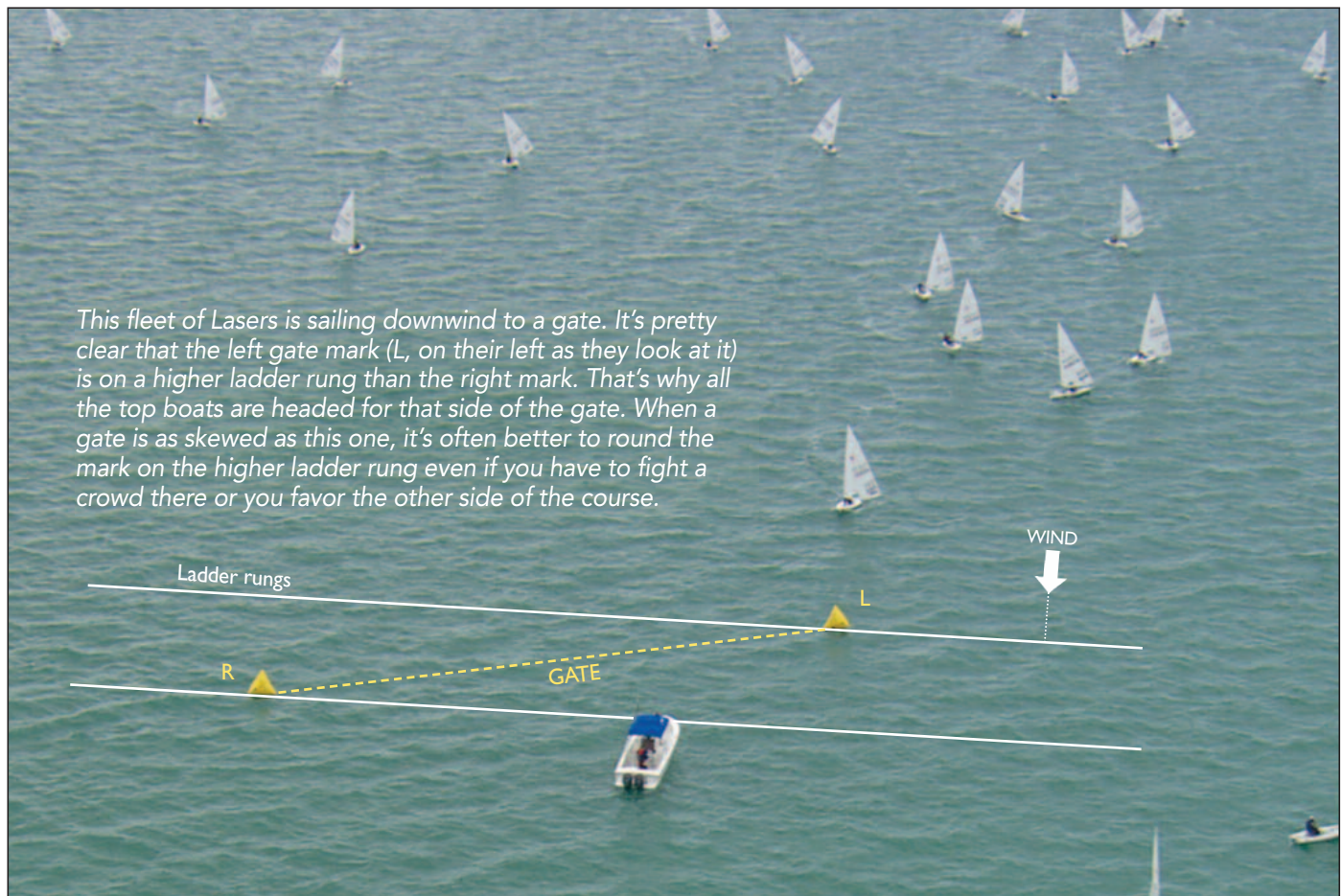
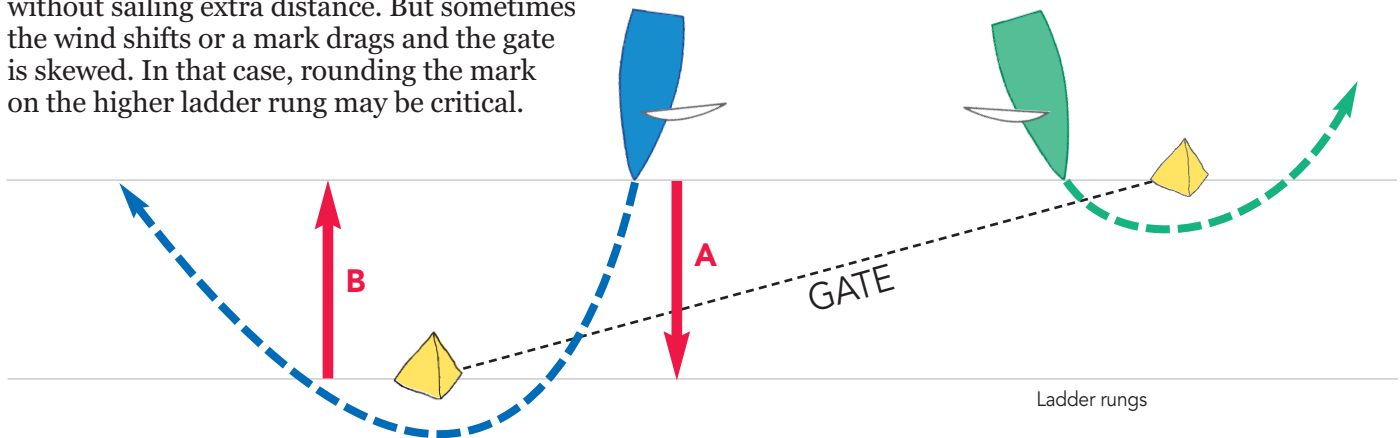
If this starting line is square to the wind, it means we're looking straight along a ladder rung. All boats that start exactly on the line, therefore, will be even in the race because they are equally advanced toward the windward mark. As soon as the wind shifts, however, the ladder rungs will change, the line will become 'skewed' and the boats closer to the wind shift will make gains.

Potential double trouble at the gate!

As you approach the gate at the end of a leeward leg, you are trying to climb down the ladder as quickly as possible. But as soon as you get to a gate mark, you have to start climbing back up the ladder toward the windward mark. In order to sail the shortest course, you should round the gate mark that is on the higher ladder rung.

A gate is a lot like the start or finish – it's a line defined by a mark at each end. In most races the race committee attempts to set the gate square to the wind direction. This means both gate marks are on the same ladder rung, so you can round either one without sailing extra distance. But sometimes the wind shifts or a mark drags and the gate is skewed. In that case, rounding the mark on the higher ladder rung may be critical.

Most leeward gates are not nearly as wide as a starting line, so boats on one side of the gate don't have as much leverage over boats on the other side. But there are two reasons why it can be very costly to round the gate mark on the lower ladder rung. The first is that you have to sail farther to reach the mark – this extra distance (A) is equal to the distance between the ladder rungs of each mark. Second, you have to sail the same distance upwind again (B) just to return to the ladder rung of the other gate mark. So unlike the start or finish line, going to the wrong end costs you two times – once downwind and then again upwind!



At the finish line, head for the closer end

A finish line is quite similar to a starting line – it's a straight segment between two marks that, in the perfect world, is set square to the wind. But often the finish line is skewed, for one reason or another, and close finishes are typically won by the boat that finishes at the end on the closer ladder rung.

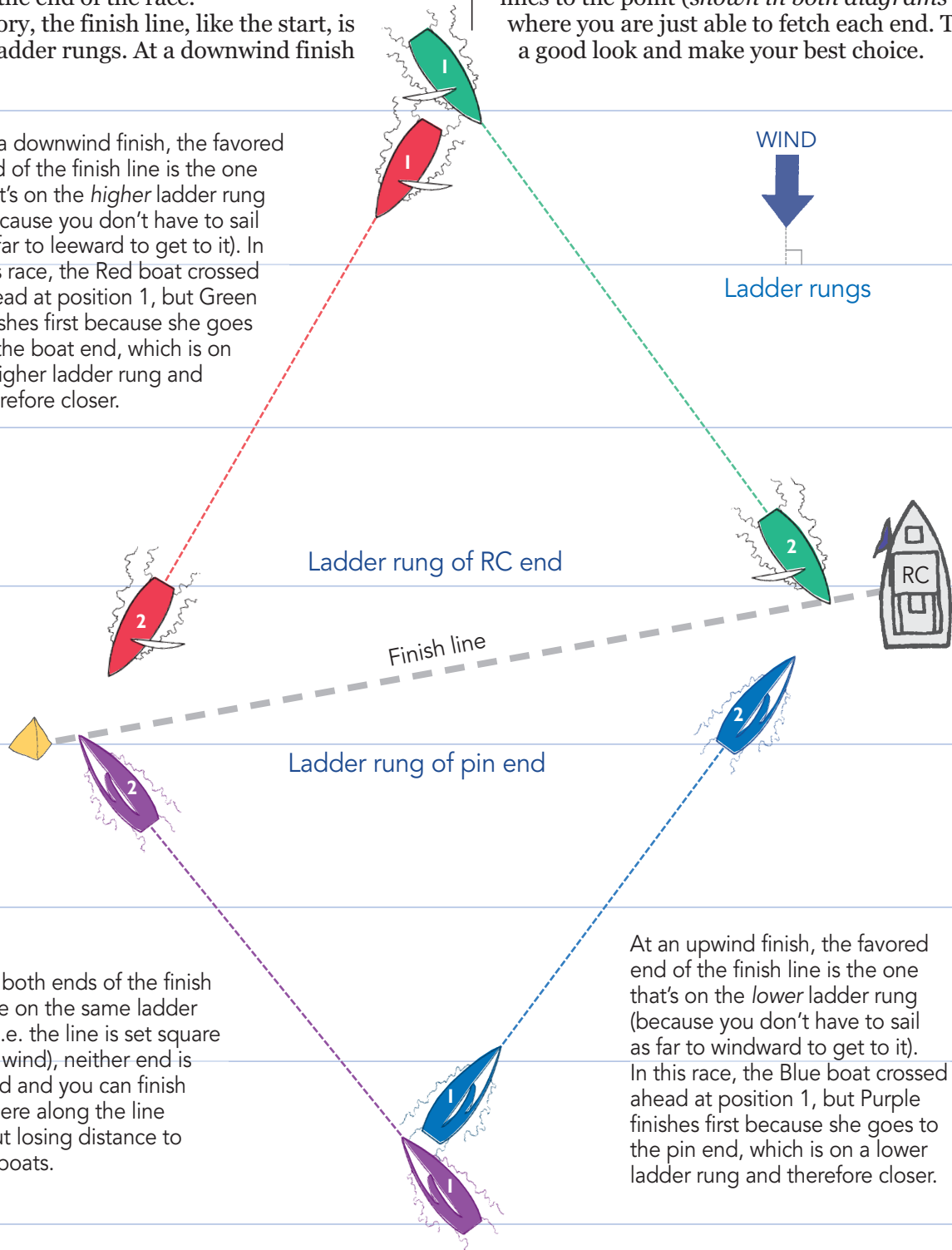
So which end is favored? That's not always easy to tell. Unlike the starting line, which boats can examine carefully as they sail around before the race, the finish line is usually not seen by competitors until they approach the end of the race.

In theory, the finish line, like the start, is all about ladder rungs. At a downwind finish

you should cross the line near the end that's on the *higher* ladder rung. This way you don't have to climb down the ladder any farther than is absolutely needed. At an upwind finish line, you should finish at the end that's on the *lower* ladder rung so you don't have to sail any extra distance to windward.

When you're not sure which end is favored, get as close to the line as possible before you have to decide where to finish. If you overstand either end of the line you've gone too far. Instead, try to sail within the laylines to the point (*shown in both diagrams below*) where you are just able to fetch each end. Then take a good look and make your best choice.

At a downwind finish, the favored end of the finish line is the one that's on the *higher* ladder rung (because you don't have to sail as far to leeward to get to it). In this race, the Red boat crossed ahead at position 1, but Green finishes first because she goes to the boat end, which is on a higher ladder rung and therefore closer.



When both ends of the finish line are on the same ladder rung (i.e. the line is set square to the wind), neither end is favored and you can finish anywhere along the line without losing distance to other boats.

At an upwind finish, the favored end of the finish line is the one that's on the *lower* ladder rung (because you don't have to sail as far to windward to get to it). In this race, the Blue boat crossed ahead at position 1, but Purple finishes first because she goes to the pin end, which is on a lower ladder rung and therefore closer.



Four ways to identify your ladder rung

Ladder rungs can be very helpful for strategy and tactics, but two problems make them a challenging tool. First, they're invisible. And second, they're constantly moving.

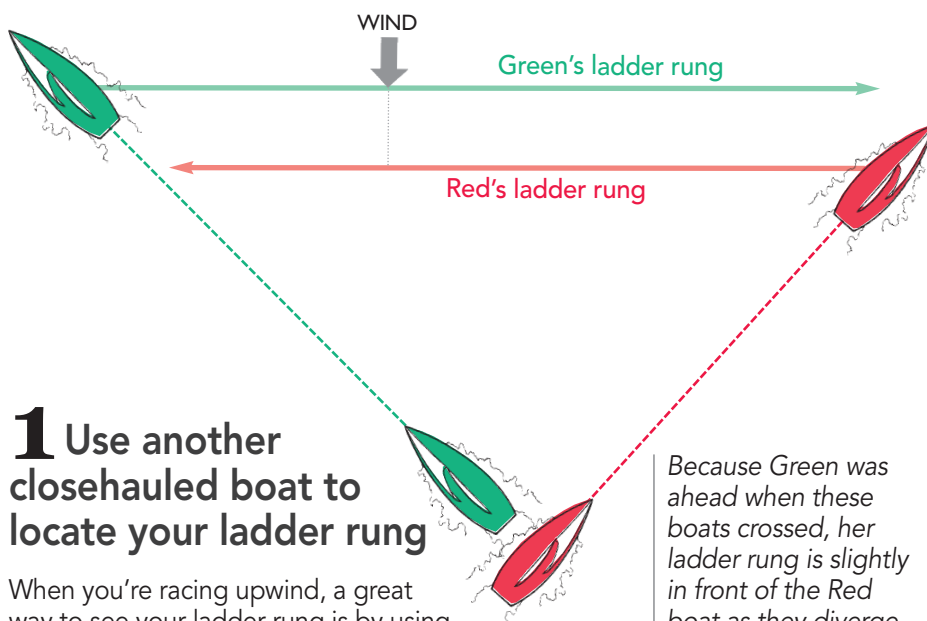
In order for the ladder concept to be helpful during a race, you must be able to identify the rung you are on. This doesn't need to be exact, but it's helpful to be fairly accurate. Here are four methods you can try, depending on the size of your boat and the leg on which you are sailing:

1. *Upwind cross* – An easy, simple technique that works on any boat after a close cross with a closehauled competitor.

2. *Downwind boom angle* – A helpful rule of thumb that works on most boats and is easy to use when you're on a run.

3. *Tacking lines* – An accurate tool you can use at any point on a beat or run, *but* you need lines drawn on your deck and the ability to sight along them during a race.

4. *Compass bearing* – A very precise way to locate your ladder rung, *but* you need a compass.



1 Use another closehauled boat to locate your ladder rung

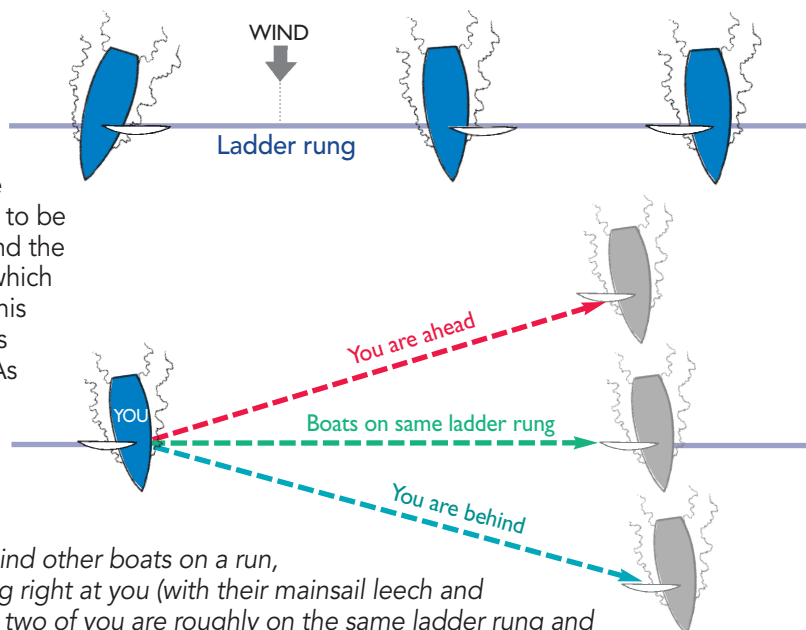
When you're racing upwind, a great way to see your ladder rung is by using a boat on the opposite tack that recently crossed just ahead of or behind you. When you duck another boat (or they duck you), keep an eye on them as you sail apart. The line from your boat to theirs represents your (and their) ladder rung, so watch how they converge with other boats and look at the fleet beyond them to get an idea of where you stand.

Of course, this technique works only when the other boat is going roughly the same speed you are, and only as long as the wind direction remains steady. Once the wind shifts you need to start over with a new boat.

Because Green was ahead when these boats crossed, her ladder rung is slightly in front of the Red boat. For the same reason Red's ladder rung is slightly behind the Green boat. As the boats get farther apart, the ladder rung becomes less exact, so it makes sense just to sight directly through the other boat.

2 Use boom angles downwind

While sailing downwind, most boats trim their mainsail so a line drawn from luff to leech is roughly perpendicular to the wind direction. This is fast because it maximizes the amount of sail area projected to the wind. It also happens to be very useful for identifying ladder rungs since the boom (and the chords of the sail) are trimmed at about 90° to the wind, which means they show each boat's approximate ladder rung. This doesn't work for all boats (some fast boats trim their mains tighter than 90°), but it's generally true most of the time. As a result you can usually sight along your boom, or look at the boom angles of other boats on either jibe, and get a good idea of where your ladder rung goes, and if you are ahead of or behind those boats.



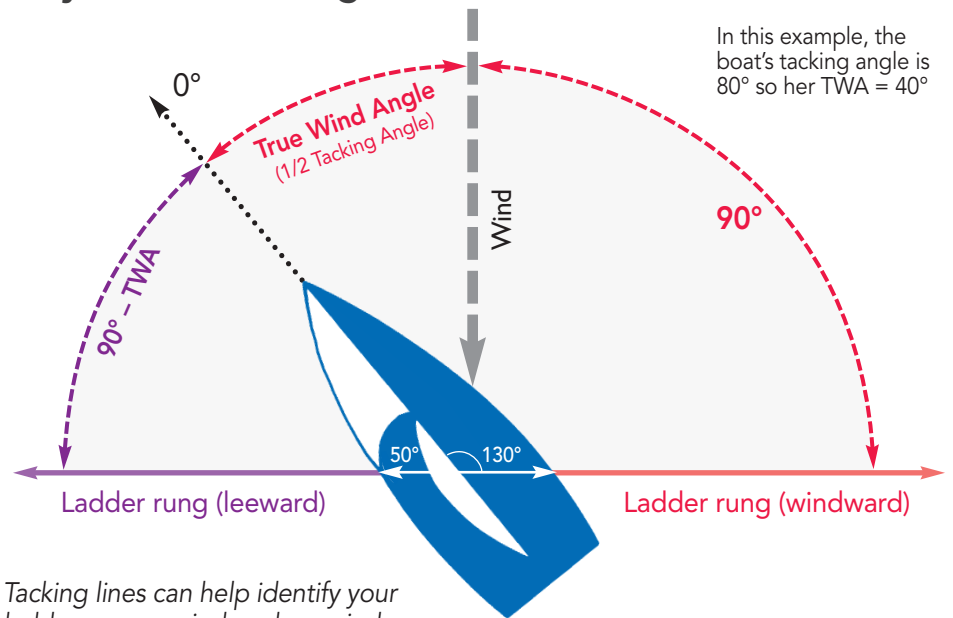
When you want to know whether you are ahead of or behind other boats on a run, look at their booms and mainsails. If their boom is pointing right at you (with their mainsail leech and luff lined up) and your boom is pointing at them, then the two of you are roughly on the same ladder rung and even in the race. If you can see the forward (leeward) side of their sail you are ahead of them; if you can see only the aft (windward) side of their main you are behind them. If you notice a change in your view of another boat's mainsail or boom, it means one of you is going faster or the wind has shifted and changed your ladder rungs.

3 Use 'tacking lines' to see your ladder rung

'Tacking lines' are a set of lines drawn like a protractor on the deck on each side of your boat. They are used to predict the course you would sail after a tack (e.g. when you are calling a layline), but they also have many other purposes.

These lines are very good for identifying the ladder rung you are on at any moment. With a bit of geometry (see right) you can figure the angle of your ladder rung (relative to your bow) and then use the angled lines on deck to sight along that rung to windward or leeward.

However, tacking lines require a few things. First, you have to know your tacking angle in the existing conditions (you can always calculate the angle between headings on each tack). You also need a space on each side of your deck to draw the lines and, more critically, you must be able to sight along those lines while racing. This is obviously tough when hiking is essential or when crew are sitting on the lines.



Tacking lines can help identify your ladder rung upwind or downwind, on either your windward or leeward side. This diagram shows a boat racing upwind. Let's assume she tacks through an angle of 80° (so 80° is her tacking angle and 40° is her true wind angle on either tack). The ladder rung on her windward side will be the line that is 130° (90° plus 40° true wind angle) aft of her bow on the starboard side. If she sights along this line she will be looking at boats that are even with her in the race. On her leeward (port) side, her ladder rung is shown by the line drawn 50° aft of her bow (90° minus 40° true wind angle).



4 Find ladder rungs with your compass

A compass is the most accurate way to identify your ladder rung. Of course, you can only use this method if you have a compass on your boat (or if you bring a hand-bearing compass which I recommend highly). Also, you need to know the wind direction (which you can get by bisecting your heading on each tack).

In the example shown here, the Red boat (#136) is racing upwind in a breeze from 225° . Her ladder rung is a line that is perpendicular to this wind, so we add 90° to get a ladder rung bearing 315° from her windward side. Or we subtract 90° to get a rung bearing 135° from her leeward side.

JH Peterson photo



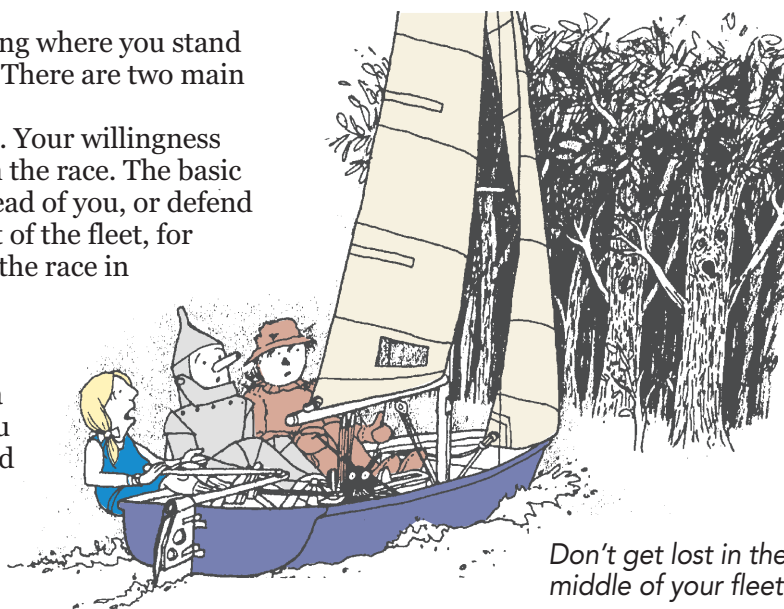
Know where you are in the fleet

We've talked about the importance of knowing where you stand in the fleet as you race around the course. There are two main reasons for this:

1) *It helps you decide how much risk to take.* Your willingness to assume risk depends a lot on your position in the race. The basic question is whether you will attack the boats ahead of you, or defend against the boats behind. If you're near the front of the fleet, for example, you will probably approach the rest of the race in a different way than if you're near the back.

2) *It helps you make tactical and strategic decisions.* If you're thinking of tacking or jibing, it's key to know whether you'll be able to cross a starboard tacker on your hip. And where will you converge with a nearby pack of boats? That could have a big impact on your decisions.

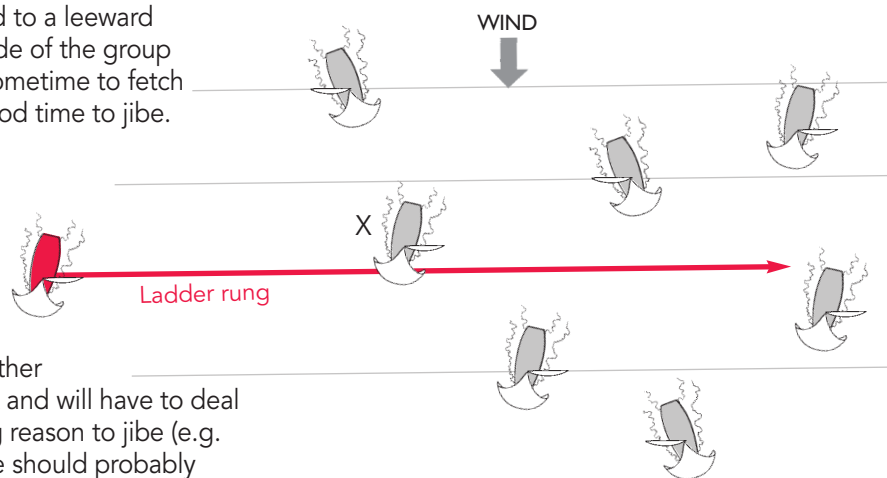
One of the best ways of estimating your position is by using ladder rungs. Here are some situations where they can be helpful.



Don't get lost in the middle of your fleet!

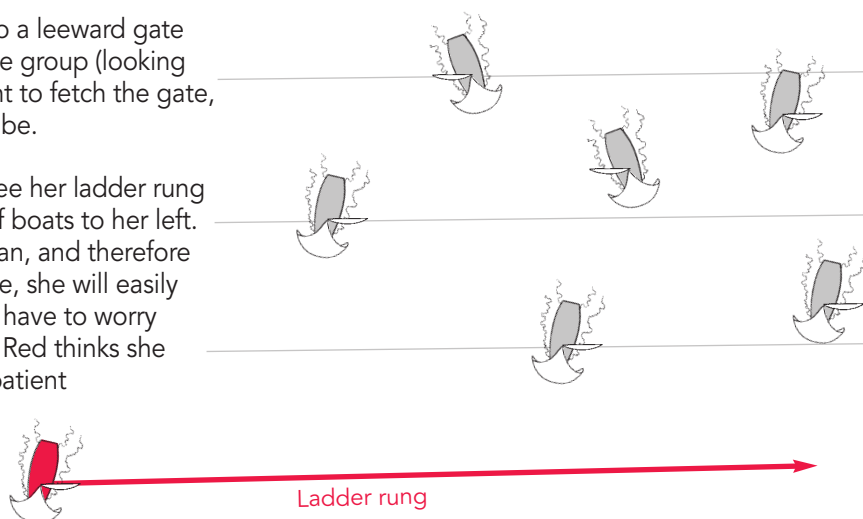
Situation A: The fleet is racing downwind to a leeward gate mark with the Red boat on the right side of the group (looking downwind). Red will have to jibe sometime to fetch the gate, so she is wondering if now is a good time to jibe.

Comments: Red sights along her boom to see her ladder rung and evaluate where she stands in the pack of boats to her left. She notices two potential problems with jibing: 1) She cannot cross ahead of the boat (X) that is closest to her and has the right of way; and 2) When she gets to the other side of X she will be in the middle of a pack and will have to deal with bad air, etc. So unless Red has a strong reason to jibe (e.g. she sees a lot more pressure to her left), she should probably stay where she is with clear air until she gets closer to the layline.



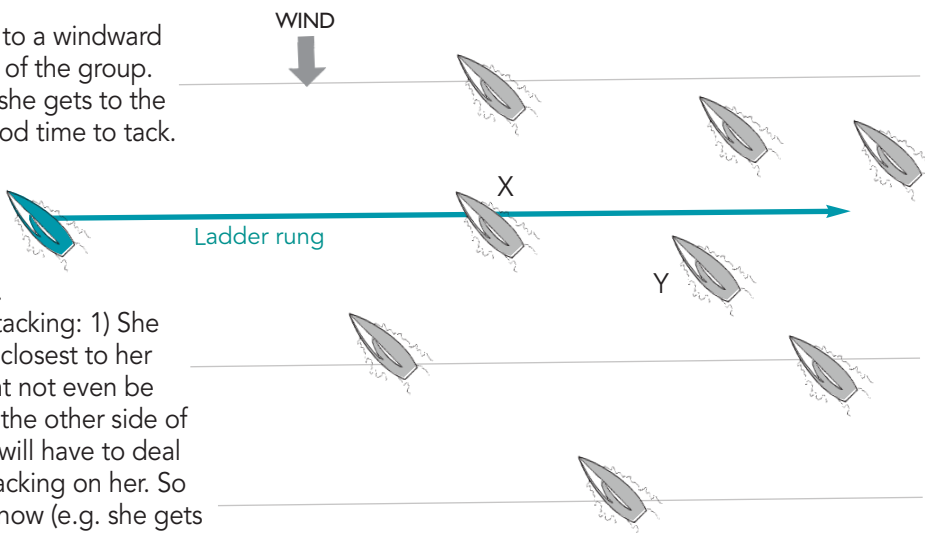
Situation B: The fleet is racing downwind to a leeward gate mark with the Red boat on the right side of the group (looking downwind). Red will have to jibe at some point to fetch the gate, so she is wondering if now is a good time to jibe.

Comments: Red sights along her boom to see her ladder rung and evaluate how she's doing with the pack of boats to her left. She sees that she is clearly on a lower rung than, and therefore ahead of, all the nearby boats. Even with a jibe, she will easily cross in front of the pack to her left and won't have to worry about bad air. Therefore, it's OK to jibe. But if Red thinks she will maintain this position, she can be a little patient and wait for the best time to jibe (e.g. when the wind shifts right). One reason to jibe now is to get in a better covering position between other boats and the next mark.



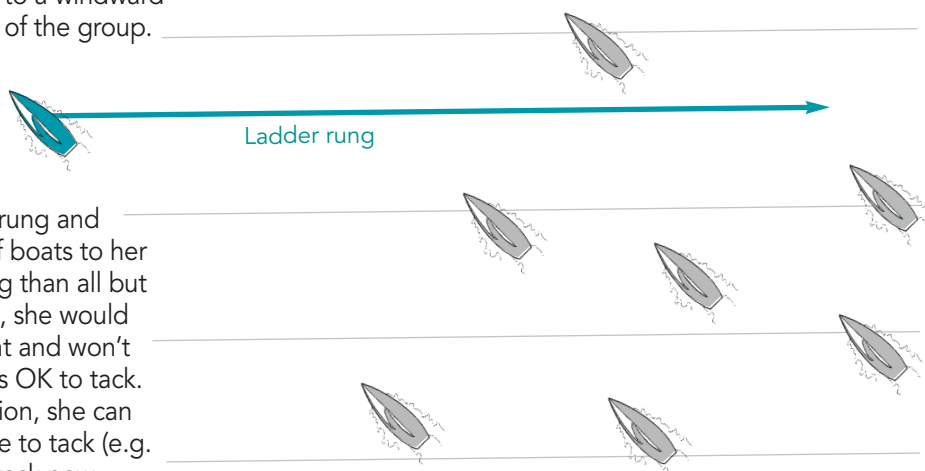
Situation C: The fleet is racing upwind to a windward mark with the Green boat on the left side of the group. Green will have to tack sometime before she gets to the layline, so she is wondering if now is a good time to tack.

Comments: Green uses the tacking lines on her starboard side to see her ladder rung and evaluate where she stands with the pack of boats to her right. She notices two potential problems with tacking: 1) She cannot cross ahead of the boat (X) that is closest to her and has the right of way (in fact, she might not even be able to cross Y); and 2) When she gets to the other side of X she will be in the middle of a pack and will have to deal with bad air and the possibility of boats tacking on her. So unless Green has a strong reason to tack now (e.g. she gets a big header), it might be better to wait patiently where she is with clear air until she gets closer to the layline.



Situation D: The fleet is racing upwind to a windward mark with the Green boat on the left side of the group. Green will have to tack sometime before she gets to the layline, so she is wondering if now is a good time to tack.

Comments: Green sights through a hand-bearing compass to see her ladder rung and evaluate how she's doing with the pack of boats to her right. She sees that she is on a higher rung than all but one of the nearby boats. Even with a tack, she would easily cross in front of the pack to her right and won't have to worry about bad air. Therefore, it's OK to tack. If Green thinks she will maintain this position, she can be more patient and wait for the best time to tack (e.g. when the wind shifts left). One reason to tack now would be to get in a better covering position.



Knowing where you stand relative to other boats in the fleet is often key to making smart strategic and tactical decisions, especially right after the start when boats are close together. In this photo, Boat 103 got a good start and has a nice lane on starboard tack. But what if she finds a reason to head toward the right side? Should she tack now?

A big question mark is whether 103 can tack and cross in front of X, Y and, more importantly, Z (the boat on starboard just beyond 222). This depends on whether 103 is advanced enough on the other boats to tack and still cross them. If not, she will end up making two costly tacks, or ducking Z and getting sucked back into the pack. In that case it might be better for her to wait a minute and see if she can extend her lead a little.



Can you tack and cross a boat on your hip?

When you're on starboard tack and your strategic plan says to go right, it's often tough to know whether you can tack to port and safely cross a starboard tacker on your windward hip. If you get this wrong you'll end up doing a costly second tack, a huge duck or two turns for fouling.

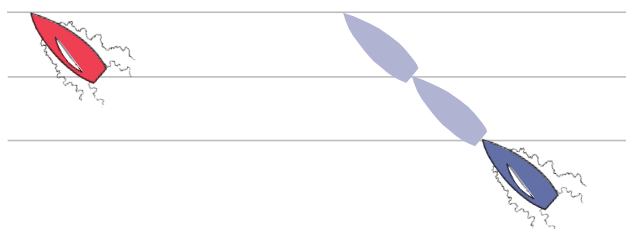
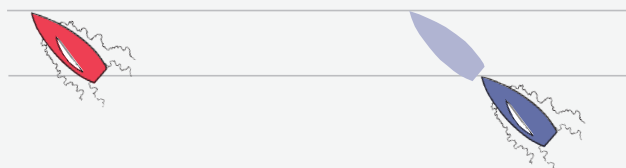
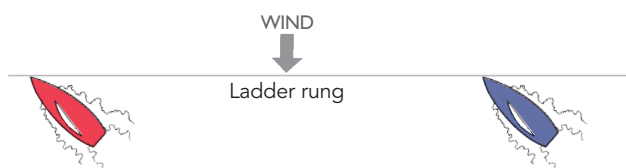
In most cases you need to be farther ahead than you think, especially when the other boat is fairly close to windward. If you're looking at the situation and

thinking it's going to be a close call, it probably will be, so maybe it's better to wait a bit and reassess.

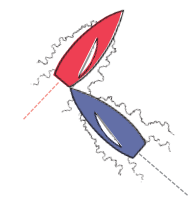
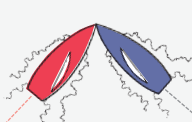
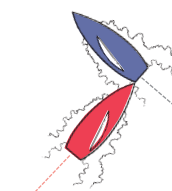
To cross in front of the other boat without fouling, you need to be ahead of them (i.e. on a higher ladder rung) by a certain amount before you tack. The minimum distance is the sum of three things: 1. The distance you lose by tacking; 2. The length of your boat, and 3. A safety factor in the existing conditions. Check out the notes below for more on this.

Position before tacking

(Assume each boat loses 1 length in a tack; if they lose more, the margin needed to cross safely will be greater.)



What the cross will look like

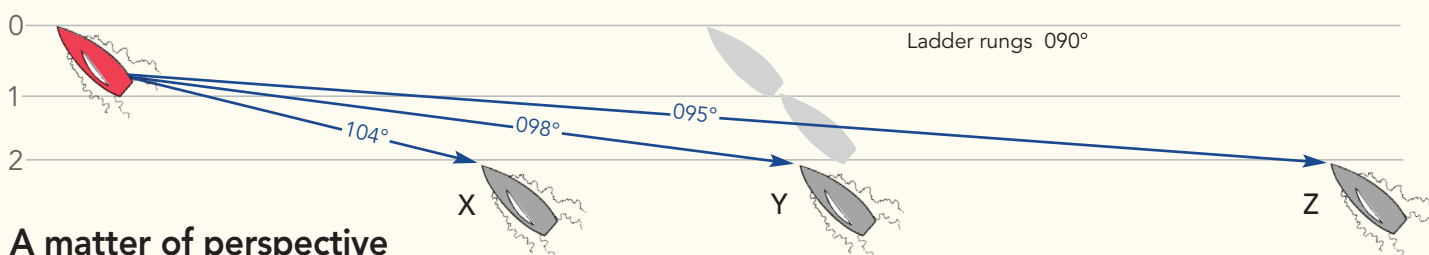


Notes

The boats started on the same ladder rung, so they were **even** (bow-to-bow) in the race. When Red tacks she will lose one boatlength, so her bow will be at Blue's transom when the boats come together. Red is nowhere close to crossing ahead of Blue (but at least she won't have to duck much to go behind Blue).

The boats started on different ladder rungs with Red ahead of Blue by **one** boatlength. When Red tacks she will lose one boatlength, so the boats will be bow-to-bow as they come together. Even though Red was a boatlength ahead before her tack, she still has no chance to cross Blue; she is not even positioned to do a strong lee-bow tack here.

The boats started on different ladder rungs with Red ahead of Blue by **two** boatlengths. When Red tacks she loses one boatlength, so her transom will be at Blue's bow when they come together. This is the minimum distance Red needs before she even thinks about trying to tack and cross Blue, but she still has not left any margin for error or safety.



A matter of perspective

If you want to cross a starboard tacker on your hip and a tack costs one boatlength, you need to be at least two lengths ahead of that boat in order to tack and cross safely. This is true no matter how much lateral distance separates the boats: You have a chance to cross only when the other boat is on a ladder rung at least 2 lengths below yours.

In this diagram Red may be able to tack and cross X, Y and Z who are all just over two lengths behind. But the bearing to each of these boats is quite different, depending on how far away they are. Red can cross Z when Z bears 095°, but she can't cross X, which is much closer, until the bearing to X is at least 104°. This is a huge difference in perspective.



Here's another start where a boat on starboard tack (3991) is trying to tack, cross the boats on her windward hip, and head to the right side. Will she make it? The success of this move depends on two things: 1) how much distance she loses in the tack, and 2) how far she was ahead of the other boats before she began her tack.

Because the boats she will have to cross are very close to her, she needs to be quite advanced in terms of bearing on them (see bottom of page 14). She also wants to be quite sure, before tacking, that she will be able to cross, since an error here would mean another immediate tack, a huge duck or a foul.

JH Peterson photo

Don't be fooled by tacking angles

Not all boats sail the same angles upwind. Some tack through a wide arc of 90 or 100 degrees, while others have a tacking angle of only 65 or 70 degrees! Even the most close-winded boats don't point very high in light air and chop. But when it comes to ladder rungs, tacking angles don't matter. That's because ladder rungs are always perpendicular to the wind direction – they aren't affected by wind velocity, tacking angle or any other aspect of boat performance. However, the variation in tacking (and jibing) angles due to boat type and wind/wave conditions can make it difficult to judge ladder rungs and the relative positions of boats.

A practice drill If you have trouble knowing whether or not you can tack and cross a windward boat, try this idea the next time you have a chance to do some speed testing with another boat: Start the test with the leeward boat slightly more bow-forward than normal, and have her tack as soon as she thinks she might be able to cross in front of the windward boat. If you do

this a bunch of times you will get much better at estimating how far ahead you must be in order to cross safely.

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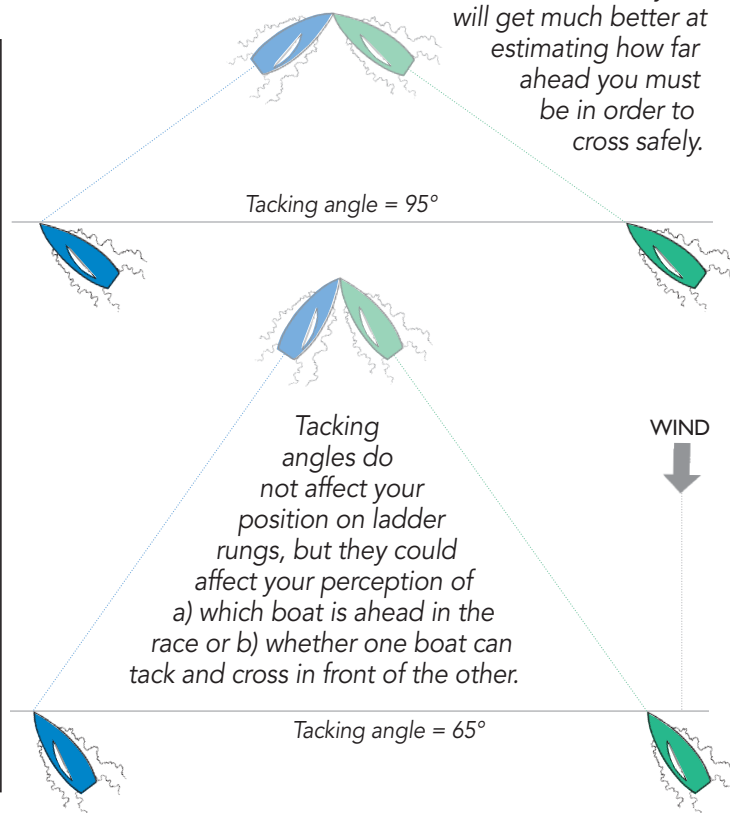
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At the leeward mark:

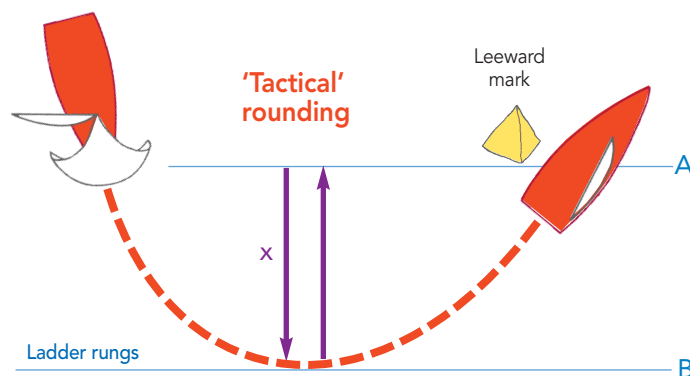
Why you should avoid 'tactical' roundings whenever possible

When you're approaching the leeward mark, a 'tactical' rounding (*right*) is often the best course. By swinging wide and then cutting tight you will be closehauled when your bow reaches the mark. This allows you to point high as you exit the mark, which is important when you are trying to 1) avoid the bad air of a boat just in front of you; or 2) tack cleanly ahead of a boat that rounded just behind you.

But a tactical rounding is not always the fastest way around a leeward mark. When you're not worried about height right after the mark, the 'swing-wide, cut-close' rounding is definitely slow, and we can use ladder rungs to explain why.

When you're sailing downwind, your goal is to climb *down* the ladder to the leeward mark. Once you get to the leeward mark, you start climbing *up* the ladder toward the windward mark. In order to sail the shortest course, you shouldn't go any farther past (to leeward of) the mark than you absolutely must. It's like a running race where you have to go around a tree and back; the fastest course is to cut the tree as close as possible, not run way beyond it.

The same is true at a mark. The ideal 'strategic' rounding (the course you would sail when you're not worried about other boats) is to go just far enough down the ladder to get around the mark (*right*). In other words, the mark should be at the bottom of your turn (on the lowest ladder rung within your arc), and you should pass it close aboard on a beam reach. That is the quickest way to get around the mark and start going back upwind.



In the absence of other boats, the tactical rounding above is not the fastest way to sail the course. That's because the Red boat sails all the way down to ladder rung B when she only has to sail to ladder rung A. Red sailed past the mark by the distance X; then she had to sail X again just to get back to the mark. So this rounding costs her a distance of 2X compared to the faster strategic rounding below.

